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Evaluation of kukui oil (*Aleurites moluccana*) for controlling termites

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ABSTRACT

The application of many chemical-based pesticides to protect wood has been greatly restricted in the United States and elsewhere. A possible natural product that can be used for wood preservation is the oil from the nut of the kukui plant, *Aleurites moluccana* (L.) Willd., which has been reported, based on native folklore, to protect canoes against marine borer damage. The objective of this study was to determine whether the kukui oil would have termite control properties.

Oil obtained by mechanical pressing of the nut from the kukui plant was used to treat southern yellow pine (*Pinus* spp.) wood. Wood blocks were impregnated with various mixtures of the oil and acetone using a vacuum-pressure-infiltration chamber to attain a range of oil contents in the wood. Laboratory studies with the Formosan termite (*Coptotermes formosanus*) showed that the oil-treated wood was resistant to termite damage when the wood contained >27% kukui oil by weight. Results also indicated that the oil acted primarily as a feeding deterrent and not a toxic agent.

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1. Introduction

Major scientific effort has been directed toward developing medicinals from plants based on native folklore. However, research aimed at developing insect pest control has played a minor role. Oil derived from the nut of the kukui (candlenut, lumbang, varnish, Indian walnut, Belgium walnut, kemiri) tree has been reported to be a good wood preservative (Wilcox, 1916) and buildings treated with the oil remained intact for 15–20 years. The oil was applied to watercrafts to protect them against marine borers (Duke, 2000). A large quantity was used to water-proof wooden-hulled sailing vessels (Wilcox, 1916) and the kukui oil market was a thriving business until wood was replaced with metal and with the introduction of improved polymeric coatings. Thus, interest in kukui oil as a wood preservative eventually declined. Limited application of kukui still continues for medicinal and food purposes in modern culture. More recently, kukui oil has been used as an emollient in skin care products (Ako et al., 1993).

The tung tree (*Aleurites fordii*, Hemsl.), a close relative of the kukui tree, has received more attention and widely used as an ingredient for manufacturing lacquer, varnish, paint, and polish (Duke, 1983). Krauss (2001) indicated that the kukui oil has been used as a wood finish for storage utensils. Modifying kukui oil for finishing wooden furniture (Eusebio et al., 1994) has been done, but the finding has not been commercially applied. Both the tung and kukui trees are widely distributed in Polynesia, India, Philippine, Malaysia, Australia, and other Pacific Islands and attempts have been made to hybridize the two species (Wilcox, 1916).

Up to the end of the 20th century, few studies have been reported on the insect control properties of these two oils. Hutchins (2001) showed that extracts from tung wood and meal had antitermitic properties. The obvious next question is whether the kukui oil with similar genetic origin as the tung would have termite control properties. Also based on native folklore on kukui oil as a wood preservative, raised challenging possibilities about the insect control property of this oil. Thus, the objective of this study was to determine whether kukui oil when incorporated into wood will provide protection against termite attack.

2. Materials and methods

2.1. Kukui oil

The oil was obtained by passing whole kukui nut kernel with a screw-type extruder at room temperature. The special batch of filtered raw oil, supplied by Oils of Aloha, Wailua, Hawaii, was clear and light brown in color. No additional treatment was made to the oil except that it was diluted with acetone to obtain oil concentrations ranging from 6.5, 12.3, 24.8, 50.0, and 66.0% (v/v) for impregnation into the wood blocks.

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Table 1
Comparison of weight loss between wet blocks treated with kukui nut oil and untreated blocks 1, 2, 3, and 4 weeks after exposure to *C. formosanus* in a feeding choice bioassay.

Treatment % (w/w)	Weight loss (mg) and *t* statistics (mean ± SD) 1 week				2 weeks			
	Treated	Untreated	*t*	*P*	Treated	Untreated	*t*	*P*
47.00	0.0 ± 0.0	21.1 ± 6.5	42.64	0.0060	20.5 ± 41.0	584.5 ± 83.2	148.0	0.0001
43.73	0.0 ± 0.0	17.6 ± 9.2	14.71	0.0086	9.5 ± 18.9	500.9 ± 178.6	29.96	0.0016
27.81	0.0 ± 0.0	19.0 ± 7.5	25.37	0.0024	35.5 ± 42.6	307.3 ± 97.5	26.1	0.0022
16.56	16.0 ± 17.5	19.2 ± 15.2	0.08	0.7927	84.4 ± 76.3	349.2 ± 146.2	10.31	0.0184
9.09	7.3 ± 9.7	30.7 ± 13.7	7.73	0.0320	113.2 ± 98.2	497.6 ± 121.3	24.25	0.0026
5.28	11.1 ± 14.1	23.4 ± 11.9	1.78	0.2309	105.6 ± 116.6	311.0 ± 85.5	8.08	0.0295
Acetone	17.3 ± 8.3	8.8 ± 9.4	1.80	0.2280	340.3 ± 192.3	453.5 ± 208.0	0.64	0.4548
Untreated	5.8 ± 7.3	17.3 ± 11.3	2.95	0.1366	233.6 ± 177.9	451.2 ± 268.9	1.82	0.2257

Treatment % (w/w)	Weight loss (mg) and *t* statistics (mean ± SD) 3 weeks				4 weeks			
	Treated	Untreated	*t*	*P*	Treated	Untreated	*t*	*P*
47.00	35.1 ± 70.3	1226.6 ± 426.2	30.44	0.0015	35.2 ± 70.3	1388.6 ± 375.6	50.18	0.0004
43.73	73.6 ± 105.3	959.4 ± 165.8	81.36	0.0001	87.5 ± 132.7	1156.0 ± 253.8	55.69	0.0003
27.81	109.8 ± 58.4	608.6 ± 61.9	137.5	0.0001	111.6 ± 92.0	722.7 ± 111.9	71.20	0.0002
16.56	145.0 ± 144.0	612.3 ± 94.8	29.39	0.0016	157.4 ± 158.0	829.7 ± 80.1	57.74	0.0003
9.09	209.0 ± 165.3	723.9 ± 171.3	18.72	0.0049	209.1 ± 165.3	799.3 ± 169.0	24.93	0.0025
5.28	238.6 ± 227.7	588.4 ± 242.1	4.43	0.0799	296.9 ± 251.9	662.6 ± 226.6	4.66	0.0742
Acetone	572.2 ± 435.3	780.3 ± 362.4	0.54	0.4902	602.2 ± 435.6	816.8 ± 394.3	0.53	0.4925
Untreated	481.1 ± 230.9	634.9 ± 303.5	0.65	0.4507	505.3 ± 225.9	708.0 ± 329.0	1.03	0.3488

2.2. Oil treatment

Southern yellow pine (*Pinus* spp.) wood blocks approximately 25.4 mm square and 9 mm thick were impregnated with different concentrations of the kukui oil–acetone mixtures as noted in the preceding section. For oil infiltration, wood blocks were placed into a cylindrical, steel, air-tight, cylindrical pressure chamber (65 mm diameter × 125 mm long) and evacuated for 20 min. After the chamber was filled with wood blocks, it was evacuated and the oil–acetone solution was introduced into the chamber. Adequate amount of the oil mixture was delivered into the chamber to make sure that the wood blocks were set below the liquid surface. Steel washers were previously placed on top of the blocks to prevent the wood from floating above the solution. The chamber was then subjected to 690 kPa pressure with nitrogen gas for 30 min. The oil-impregnated wood blocks were removed, the excess solution wiped off with tissue paper, and the blocks dried in a vacuum oven at 60 °C for 24 h. This procedure was used to remove the acetone fraction. The wood surface was smooth with no tackiness and no sign of excess oil. The oil content of the oil-treated wood (%, w/w) was determined based on the gain in weight of the untreated wood.

Table 2
Comparison of weight loss between dried blocks treated with kukui nut oil and untreated blocks after 4-week exposure to *C. formosanus* in a multiple diet choice feeding bioassay.

Treatment % (w/w)	Weight loss (mg) and *t* statistics (mean ± SD) 4 weeks			
	Treated	Untreated	*t*	*P*
47.00	23.0 ± 20.1	504.5 ± 105.9	79.85	0.0001
43.73	16.6 ± 24.7	553.1 ± 181.3	34.38	0.0011
27.81	44.6 ± 17.1	472.2 ± 95.0	78.44	0.0001
16.56	185.6 ± 100.6	462.1 ± 157.4	8.77	0.0253
9.09	282.7 ± 143.2	366.4 ± 43.5	1.25	0.3063
5.28	445.8 ± 508.1	301.9 ± 55.7	0.28	0.6172
Acetone	581.8 ± 418.8	203.1 ± 137.5	2.95	0.1365
Untreated	235.6 ± 84.5	240.1 ± 80.8	0.01	0.9416

2.3. Termite source

Four colonies of *Coptotermes formosanus* were obtained from field sites in New Orleans, Louisiana. Colonies were collected from the USDA Southern Regional Research Center or the University of New Orleans. The termites were collected with bucket traps (Su and Scheffrahn, 1986) and maintained on stacked, water soaked, spruce (*Picea* spp.) slates (100 mm × 40 mm × 5 mm) in plastic containers (130 mm × 130 mm × 40 mm) maintained at about 100% relative humidity and 26.6 °C. Termites were identified using keys for soldier identification from Scheffrahn and Su (1994) and Su et al. (1997).

2.4. Termite testing

Feeding deterrence and lethal effects of the test materials were determined using the choice and no-choice bioassays similar to that described by Su and Scheffrahn (1989).

2.4.1. Choice bioassays

Wooden pine (*Pinus* spp.) blocks (24 mm × 24 mm × 7 mm) were labeled with thumb tacks and dried at 60 °C for 48 h to obtain dry weights (±0.1 mg). The wood blocks tested contained kukui oil contents of 47.0, 43.73, 27.81, 16.56, 9.09, and 5.28% (w/w). Acetone treated pine and untreated pine were also bioassayed. Sand (75 ml) moistened with 18 ml deionized water was added to screw-top jars (6.5 cm diameter, 8 cm high). Two dry wood blocks were placed on the sand's surface with their respective edges against opposing sides of the container. One wood block was impregnated with a treatment and the other was untreated, except for controls. The experimental units were allowed to equilibrate for 6 days prior to the introduction of termites to obtain wet weights of the blocks. One hundred workers (undifferentiated larvae of at least third instar, as determined by size) plus five soldiers were placed on the moist sand in the jars. Four experimental units (replicates) were set up for each treatment, with each unit receiving termites from a different colony. Experimental units were held at 26.6 ± 1 °C at 1, 2, 3, and 4 weeks, wet weights were obtained for the blocks from each block and ASTM ratings were also determined for each

Table 3
Comparison of ASTM ratings between blocks treated with kukui oil and untreated blocks 1, 2, 3, and 4 weeks after exposure to *C. formosanus* in a feeding choice bioassay.

Treatment % (w/w)	ASTM rating of wood and *t* statistics (mean ± SD)[a] 1 week: Treated	Untreated	*t*	*P*	2 weeks: Treated	Untreated	*t*	*P*
47.00	10.0 ± 0.0	7.0 ± 0.0	Infinity	0.0001	9.8 ± 0.5	4.0 ± 0.0	529.00	0.0001
43.73	10.0 ± 0.0	7.0 ± 0.0	Infinity	0.0001	10.0 ± 0.0	1.8 ± 3.5	22.22	0.0033
27.81	10.0 ± 0.0	7.0 ± 0.0	Infinity	0.0001	10.0 ± 0.0	1.0 ± 2.0	81.00	0.0001
16.56	7.0 ± 0.0	7.0 ± 0.0	0.0	None	7.0 ± 0.0	1.8 ± 3.5	9.00	0.0240
9.09	8.0 ± 1.2	7.0 ± 0.0	3.00	0.1340	6.3 ± 1.5	3.8 ± 2.9	2.38	0.1738
5.28	7.0 ± 0.0	7.0 ± 0.0	0.0	None	5.5 ± 1.7	3.8 ± 2.9	1.09	0.3369
Acetone	7.0 ± 0.0	8.0 ± 1.2	3.00	0.1340	5.5 ± 1.7	6.8 ± 2.1	0.86	0.3890
Untreated	8.5 ± 1.0	7.0 ± 0.0	9.00	0.0240	5.5 ± 1.7	4.8 ± 1.5	0.43	0.5370

Treatment % (w/w)	ASTM rating of wood and *t* statistics (mean ± SD) 3 weeks: Treated	Untreated	*t*	*P*	4 weeks: Treated	Untreated	*t*	*P*
47.00	9.3 ± 1.5	0.0 ± 0.0	152.1	0.0001	9.3 ± 1.5	0.0 ± 0.0	152.11	0.0001
43.73	10.0 ± 0.0	0.0 ± 0.0	Infinity	0.0001	9.8 ± 0.5	0.0 ± 0.0	152.11	0.0001
27.81	9.3 ± 1.5	0.0 ± 0.0	152.11	0.0001	9.3 ± 1.5	0.0 ± 0.0	152.11	0.0001
16.56	5.5 ± 1.7	0.0 ± 0.0	40.33	0.0007	4.8 ± 1.5	0.0 ± 0.0	40.11	0.0007
9.09	6.3 ± 1.5	1.0 ± 2.0	17.64	0.0057	5.5 ± 1.7	0.0 ± 0.0	40.33	0.0007
5.28	5.5 ± 1.7	3.8 ± 2.9	1.09	0.3369	5.5 ± 1.7	3.8 ± 2.9	1.09	0.3369
Acetone	5.5 ± 1.7	6.0 ± 2.5	0.11	0.7502	4.0 ± 0.0	5.0 ± 3.9	0.26	0.6278
Untreated	4.5 ± 3.3	4.0 ± 0.0	0.09	0.7732	4.5 ± 3.3	4.0 ± 0.0	0.09	0.7732

[a] ASTM scale of 10–0 with 10 being sound, surface nibbles permitted, 9 having light attack, 7 moderate attack with penetration, 4 with heavy attack, and 0 failure.

Table 4
Comparison of weight loss between blocks treated with kukui nut oil and untreated blocks 1, 2, 3, and 4 weeks after exposure to *C. formosanus* in a feeding no-choice bioassay.

Treatment % (w/w)	Water weight loss, mg (mean ± SD)[a] Wet weight: 1 week	2 weeks	3 weeks	4 weeks	Dry weight: 4 weeks
47.00	0.3 ± 0.3A	54.1 ± 56.2E	296.3 ± 331.7BCD	302.4 ± 344.0CDE	157.3 ± 47.2D
43.73	0.1 ± 0.1A	129.3 ± 131.2CDE	189.6 ± 144.2D	191.2 ± 145.8DE	254.0 ± 98.6D
27.81	2.4 ± 4.3A	116.5 ± 80.0CDE	148.7 ± 106.0D	148.7 ± 106.8E	304.2 ± 125.5CD
16.56	7.0 ± 6.0A	70.7 ± 50.2DE	239.0 ± 53.5CD	247.2 ± 67.7DE	336.3 ± 52.1BCD
9.09	22.0 ± 16.1A	237.0 ± 178.4BCDE	455.1 ± 65.2ABCD	457.8 ± 263.0BCDE	599.8 ± 138.4ABC
5.28	30.2 ± 14.5A	519.1 ± 186.6A	760.5 ± 291.2A	857.9 ± 372.4AB	545.4 ± 197.0A
Acetone	27.1 ± 14.1A	370.6 ± 360.6ABC	669.7 ± 506.0AB	766.3 ± 608.0ABC	490.3 ± 215.0ABC
Untreated	21.0 ± 8.8A	456.8 ± 218.0AB	742.6 ± 343.6A	989.1 ± 521.9A	513.2 ± 142.8AB

[a] Means followed by the same letter within a column are not significantly different ($P > 0.05$; LSD).

wood block over the same periods. The ASTM rating consisted of a scale of 10–0 with 10 being sound with surface nibbles permitted, 9 having light attack, 7 moderate attack with penetration, 4 with heavy attack, and 0 failure (ASTM, 1998). At 4 weeks, the blocks were dried and weighed as before and termite survival assessed.

Weekly wet wood block weight loss and 4-week dry block weight loss were subjected to *t* tests comparing weight loss of treated with untreated blocks. The 4-week total percent survival was subjected to ANOVA following transformation to arcsine square root of proportion survival and mean percent survival separated by LSD at $P = 0.05$ (SAS Institute, 1990).

2.4.2. No-choice bioassays

Experimental units were identical to those used in the choice bioassay, except only a single block was placed with its edge against the side of the container. Weekly wet block weight loss and 4-week dry block weight loss were subjected to ANOVA and mean weight loss separated by LSD at $P = 0.05$ (SAS Institute, 1990).

Total consumption across all treatments (choice and not choice tests) were compared by combining the 4-week dry block weight loss from the choice test treatments and subjecting all 4-week dry weight losses to ANOVA and mean weights separated by LSD at $P = 0.05$ (SAS Institute, 1990).

3. Results

3.1. Termite resistance

3.1.1. Choice bioassays

In the choice bioassays, significantly less weight loss of the treated blocks occurred after 1 week at rates above 27% kukui oil

Table 5
Comparison of ASTM ratings between blocks treated with kukui oil and untreated blocks 1, 2, 3, and 4 weeks after exposure to *C. formosanus* in a feeding no-choice bioassay.

Treatment % (w/w)	ASTM rating of wood (mean ± SD)[a] 1 week	2 weeks	3 weeks	4 weeks
47.00	9.8 ± 0.5AB	9.5 ± 0.6A	9.5 ± 0.6A	9.5 ± 0.6A
43.73	10.0 ± 0.0A	9.3 ± 0.5A	9.3 ± 0.5AB	8.0 ± 1.2B
27.91	9.0 ± 1.4ABC	8.0 ± 1.2AB	7.0 ± 0.0CD	6.3 ± 1.5C
16.56	7.8 ± 1.5CD	6.3 ± 1.5B	5.5 ± 1.7D	4.8 ± 1.5D
9.09	7.0 ± 0.0D	2.0 ± 2.3C	0.0 ± 0.0E	0.0 ± 0.0E
5.28	7.5 ± 1.0CD	1.8 ± 3.5C	0.0 ± 0.0E	0.0 ± 0.0E
Acetone	7.5 ± 1.0CD	1.8 ± 3.5C	1.8 ± 3.5E	0.0 ± 0.0E
Untreated	7.0 ± 0.0CD	3.0 ± 2.0C	0.0 ± 0.0E	0.0 ± 0.0E

[a] ASTM scale of 10–0 with 10 being sound, surface nibbles permitted, 9 having light attack, 7 moderate attack with penetration, 4 with heavy attack, and 0 failure.

Table 6
Comparison of termite survival and wood block weight loss between blocks treated with kukui oil 4 weeks after exposure to *C. formosanus* in the feeding choice and no-choice bioassays.

Treatment % (w/w)	Mean ± SD[a]			
	Choice		No choice	
	Survival, %	Total wt loss, mg	Survival, %	Total wt loss, mg
47.00	94.3 ± 3.6ABCDEF	527.4 ± 120.2BC	73.5 ± 7.2I	157.3 ± 47.2C
43.73	95.3 ± 3.8ABC	569.7 ± 191.6BC	87.0 ± 8.4BCDEFGHI	254.0 ± 98.6BC
27.81	93.8 ± 6.7ABCDE	516.8 ± 101.5BC	81.8 ± 10.2FGHI	304.2 ± 125.5BC
16.56	96.5 ± 3.5A	647.8 ± 195.2BC	91.3 ± 7.3ABCDEFGH	336.6 ± 52.1BC
9.09	93.3 ± 3.9ABCDEFG	649.1 ± 156.2BC	95.8 ± 2.6ABCD	499.8 ± 138.4BC
5.28	87.3 ± 2.1CDEFGHI	756.7 ± 469.0AB	91.5 ± 9.0ABCDEFG	545.4 ± 197.0BC
Acetone	92.8 ± 7.4ABCDE	784.9 ± 374.5AB	95.0 ± 4.7ABCD	490.3 ± 215.0BC
Untreated	79.3 ± 3.5HI	475.7 ± 146.8BC	95.8 ± 5.3DEFGHI	513.2 ± 142.8BC
No food	–	–	88.0 ± 18.8ABCDEFG	–

[a] Means followed by the same letter within a column are not significantly different ($P > 0.05$; LSD).

content (Tables 1 and 2) than the untreated blocks. These results were corroborated using the ASTM rating system (Table 3). Results were similar in the no-choice bioassay, with the highest treatment rates causing the greatest inhibition of feeding displaying a good dose response in the dry weight evaluations (Table 4). ASTM ratings were best at the kukui oil content 47% (Table 5). There was high termite survival in both choice and no-choice bioassays and a no food check at 4 weeks (Table 6). The presence of the kukui oil effect on termites feeding on untreated samples is also given in Table 6.

3.1.2. No-choice bioassays

In the no-choice bioassays, the kukui oil-treated wood blocks were less preferred than untreated pine when evaluated by weight, but were significantly less preferred using ASTM ratings (Table 5). Weight loss of treated composite was not significantly different from untreated pine when evaluated by weight (Tables 1, 2 and 4), but was significantly less preferred by ASTM ratings in both choice and no-choice bioassays (Tables 3 and 5).

4. Discussion

Although kukui and tung trees are taxonomically close relatives, they do have different uses. Duke (2000) reports no medicinal use for the fruit of the tung tree. Toxic problems have been reported for the ingestion of tung meal (Lin et al., 1996) and the leaves contain saponins that are toxic to cattle (Nellis, 1990). In contrast, the kukui nut is not considered as toxic as tung nut unless kukui is consumed by children in high amounts (Scott and Thomas, 2000). At worst, the kukui nut is a strong purgative and used in native medicine as a laxative. The cooked kukui meat is edible and has been used as thickeners and flavoring for various food preparations (Krauss, 2001). Thus, the toxicity of kukui oil does not appear to be a problem for commercial applications.

An active fatty acid component of tung oil is eleostearic acid that is not present in kukui oil (Dickey et al., 1952). Jacobson (1981) and Jacobson et al. (1981) used eleostearic acid and its methylated ester derivative to prevent boll weevil (*Anthonomus gradis gradis*) from attacking cotton bolls. Possibly, the eleostearic acid may be part of the termite control compound that was present in the solvent extraction from the tung wood and oil used by Hutchins (2001). However, the presence of eleostearic acid in kukui oil has not been reported and no active chemical compound can be related to the termite control for the oil at present.

5. Conclusion

Kukui oil extracted from the fruit of *Aleurites moluccana* provides termite resistant to wood treated at approximately 50% (w/w) oil content. In our experiment, the wood was completely impregnated with the oil. However, with surface wood treatment as in polishes or coatings, the total amount of the oil applied relative to the total weight of the wood could possibly be less. The cause of the feeding deterrent property of kukui oil is not known at this time.

Based on termite survival, kukui oil does not appear to be toxic to the insect and environmentally friendly. Kukui oil producers will be able to expand their operations and income source with the use of the oil for wood preservation treatments.

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References

Ako, H., Fujikawa, L., Gray, D., 1993. Emollient action of kukui nut oil. J. Soc. Cosmet. Chem. 44, 239–247.

American Society for Testing and Materials (ASTM), 1998. Standard test method for laboratory evaluation of wood and other cellulosic materials for resistance to termites, Standard D 3345-74. In: Annual Book of ASTM Standards 4.10. ASTM, West Conshohocken, PA, pp. 430–432.

Dickey, R.D., Gilbert, S.G., Gropp, C.M., 1952. The Genus *Aleurites* in Florida: Part I. Botanical Characteristics: Part II. Chemical and Physical Characteristics of the Oils, vol. 503. Univ. Florida Techn. Bull., Gainesville, FL, p. 40.

Duke, J.A., 1983. Handbook of Energy Crops (unpublished). http://www.hortpurdue.edu/newcrop/duke_energy/aleurites_molucanna.html.

Duke, J.A., 2000. Handbook of Nuts. CRC Press, Inc., Boca Raton, FL, p. 386.

Eusebio, G.A., Moredo, F.C., Tavita, Y.L., 1994. Piloting of lumbang oil for finishing furniture and other products. Philipp. Tech. J. 19, 27–38.

Hutchins, R.A., 2001. Tung tree extracts useful for controlling termites. U.S. Patent No. 6,264,956.

Jacobson, M., 1981. Anti-feedant for boll weevils. U.S. Patent No. 4,293,567.

Jacobson, M., Crystal, M.M., Warthen Jr., J.D., 1981. Boll weevil (*Anthonomus gradis gradis*) feeding deterrents from tung oil expressed from *Aleurites fordii*. J. Agric. Food Chem. 29, 591–593.

Krauss, B.H., 2001. Plants in Hawaiian Culture. University of Hawaii Press, Honolulu, HI, p. 227.

Lin, T.-J., Hsu, C.-I., Lee, K.-H., Shiu, L.-L., Den, J.-F., 1996. Two outbreaks of acute tung nut (*Aleurites fordii*) poisoning. J. Clin. Toxicol. 34, 887–892.

Nellis, D.W., 1990. Poisonous Plants and Animals of Florida and the Caribbean. Pineapple Press, Sarasota, FL, p. 416.

SAS Institute, 1990. A User's Guide: Statistics, 6th ed. SAS Institute, Cary, NC.

Scheffrahn, R.H., Su, N.-Y., 1994. Keys to soldiers and winged adult termites (Isoptera) of Florida. Fla. Entomol. 77, 460–474.

Scott, S., Thomas, C., 2000. Poisonous Plants of Paradise: First Aid and Medical Treatments and Injuries from Hawaii's Plants. University of Hawaii Press, Honolulu, HI, p. 178.

Su, N.-Y., Scheffrahn, R., 1986. A method to access, trap, and monitor field populations of the Formosan subterranean termite (Isoptera: Rhinotermitidae) in the urban environment. Sociobiology 12, 299–304.

Su, N.-Y., Scheffrahn, R.H., 1989. Comparative effects of an insect growth regulator, S-31183, against the Formosan subterranean termite and eastern subterranean termite (Isoptere: Rhinotermitidae). J. Econ. Entomol. 82, 1125–1129.

Su, N.-Y., Scheffrahn, R., Wessling, T., 1997. A new introduction of a subterranean termite, *Coptotermes havailandi* Holmgren (Isoptera: Rhinotermitidae) in Miami Florida. Fla. Entomol. 80, 408–411.

Wilcox, E.V., 1916. Tropical Agriculture. D. Appleton and Company, NY.